TEACHER'S GUIDE
SCIENCE KEY CONCEPTS SERIES: BIOLOGY

HOMEOSTASIS

15 minutes, Video
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FOR USE IN: Biology
LEVEL: Grades 9-12
EDUCATIONAL ADVISOR: Dr. O. Roger Anderson, Columbia University, Professor Natural Sciences, Teachers College; and Senior Research Scientist, Lamont-Doherty Earth Observatory
EDUCATIONAL OBJECTIVES:
To help the student understand these three key concepts about homeostasis:

- **Concept 1. Controlling Body Temperature**
- **Concept 2. Controlling Blood Sugar**
- **Concept 3. Controlling Water Level**

BEFORE SHOWING THE VIDEO:
During our daily experience, we use various devices to help control our environment. For example, we set a timer to control the cooking of our food or an alarm clock to awaken us at a particular time. There are even more important devices in our buildings to maintain a constant environment such as the thermostat that controls the air conditioning and heating. Living things are very complex systems and require carefully controlled internal environments to maintain life.

It may be helpful to review with students how a thermostat works in our homes. It has a set point that we can adjust for the desired temperature, it senses electronically if the temperature is at the set point or different from it. If the temperature is not at the set point, the thermostat turns on the heating or cooling devices to correct the temperature and bring it back to the set point. When the set point temperature is reached, the thermostat turns off the heating or cooling device. If a living system is not able to regulate its internal environment, it is very much at the mercy of the external environment.

Consider body temperature. Most mammals are able to control their body temperature and maintain it at a fairly constant level. Ask the students to cite some animals that cannot control their body temperature. Help them to think about the major taxonomic groups of animals such as the invertebrates including worms, insects, and crabs, or lower vertebrates such as fish, reptiles, and amphibians. Most of these organisms cannot effectively control the temperature of their bodies. Ask the students why they think lizards, some snakes, and turtles often can be seen basking in the sun. Help them to realize that the warmth of the sun is required to keep the body metabolism of those animals operating at a sufficient level to move quickly and respond promptly to stimuli, etc.

Encourage students to consider other essentials of life such as water, food, rest, and oxygen for breathing. Inquire if the students can offer evidence that the human body also carefully regulates these essentials of life. Encourage them to suggest evidence from daily experience that there are internal signals that help us maintain adequate levels of water, food, rest, etc. The students may observe that hunger is evidenced by sensations of emptiness in the stomach, or contraction of the stomach leading to "growling." Lack of sufficient water is signaled by a sense of dryness in the mouth, etc. These sensations cause us to act to remedy the need

Display a question to introduce the video using an overhead or the chalkboard. "Are there other internal mechanisms in our body that help it maintain a constant environment, even when we do not feel or recognize them?" After viewing the video, this question can be used as a focus for discussion.

CONTENT OF THE VIDEO:

The video explains the following three key concepts, each separately titled, and each running 5 minutes:
1. Controlling Body Temperature 2. Controlling Blood Sugar 3. Controlling Water Level
To play only concepts 2 or 3, simply fast-forward to its title.
Homeostasis shows how the human body keeps a constant body temperature of between 36°C and 38°C, (97 and 100 Fahrenheit), by sweating and heat radiation through the skin. Water level in the blood is maintained by the kidneys, while blood sugar level is controlled by hormones in the pancreas and liver.

Controlling Body Temperature

Jim's core body temperature is measured, through an ear probe, by a digital thermometer, as between 36°C and 38°C (97 and 100 Fahrenheit). It is maintained whatever the external temperature. Skin temperature is closer to the surrounding temperature. At 30°C (86F), through a thermal imager, the body appears blue. As the surrounding temperature rises, the image of the body goes orange as it reaches 35°C (95F).

(Question) What do you think will happen to the skin temperature on Jim's arm? (Answer) Skin helps regulate temperature. Capillaries dilate, the skin flushes and heat is lost by radiation to the surroundings. As sweat evaporates, heat energy is taken from the skin. When Jim's body cools, his skin goes pale (capillaries constrict), goose bumps appear as hairs stand up, and he starts shivering.

(Question) How do goose bumps and shivering help to keep his core temperature steady? (Answer) Goose bumps form when hairs are raised to trap an insulating layer of air around the body (a vestigial response from when earlier primates had more hair and the warming effect was more pronounced). Shivering, which is a muscular activity, increases heat production.

Controlling Blood Sugar

Carbohydrates are broken down to simpler sugars, the simplest being glucose.

The blood sugar of two subjects who have not eaten since yesterday are both measured at about 5 millimoles/ litre. They both consume 100g of glucose and their blood sugar rises to about 8 millimoles/litre (mm/l). Then one subject exercises and the other relaxes. Half an hour of exercise reduces that person's blood sugar level back to 5mm/l. However, even without exercise, the blood sugar level of the relaxing person has also been regulated so as to significantly drop. Computer animation shows how the pancreas and liver regulate the blood sugar level. When the blood sugar (glucose) level is high, the pancreas, sensing that, produces insulin, and the insulin triggers the liver to remove glucose from the blood and to store it as glycogen. When sugar is low, the pancreas produces glucogon, which stimulates the liver to convert its stored glycogen back into glucose and release it into the blood stream. Diabetics, whose pancreas does not produce enough insulin, must inject it to control their level of blood sugar.

Controlling Water Level

We take in water through drinking and eating. We lose water by breathing out, sweating and in feces and urine.

Lisa has had nothing to drink since yesterday and she has been exercising. She is dehydrated and produces a small volume of dark yellow urine. Joanne has had plenty to eat and drink. She is fully hydrated and produces far more, much paler, urine. Both subjects drink a liter of water and then pass urine every half-hour. The color and

quantity of their urine is noted under differing degrees of dehydration and hydration..

The function of the millions of nephrons in the kidneys is to filter the blood in order to regulate the blood's water level, and to eliminate excess water and waste as urine.

(Question) If you are dehydrated, what happens in your kidneys? (Answer) The nephrons will reduce the amount of water they eliminate, and the resulting urine will be less in quantity and much darker in color.

AFTER SHOWING THE VIDEO:

Ask the students to address the question displayed before showing the video; "Are there other (than temperature) internal mechanisms in our body that help it maintain a constant environment, even when we do not feel or recognize them?" Ask the students to cite the three characteristics of our body presented in the video that are controlled to keep them at a rather constant level. These should include body temperature, water level, and blood glucose. Focus on one of these.

Help the students to refine their answers by asking how does the body actively maintain a given level or set point. Using the thermostat example, ask the students to explain the homeostatic control processes in terms of the thermostat. Place categories on the board: "Set Point" "Reaction to increase" "Reaction to decrease."

Ask the students to fill-in and explain these three functions for each of the three physiological variables cited in the video. That is, for temperature, water level, and blood glucose, what is the set point and how does the body react to excess or inadequacies? The set point for human body temperature is 98 Fahrenheit, our blood typically has a volume at c. 9% of total body weight, and blood glucose during fasting is c. 5 millimoles per liter (5 mM). When the information is complete, encourage the students to compare the three physiological functions. Which of the control mechanisms depend on changes in the physical characteristics of the body, such as changes in anatomy or structure? Which of them depends on changes in chemistry and molecular regulators (hormones for example) as the basis for their control. This should help the students realize that homeostasis or maintaining a constant internal state involves a variety of mechanisms, all of which, however, are united by the common theme that they act to maintain a constant condition in the body. This involves sensing variations from the optimal condition, determining whether there is an excess or deficiency, and responding appropriately to restore the optimal level either by physical or chemical internal changes.

INTERNET WEB SITES FOR FURTHER INFORMATION:

Some useful websites on homeostasis.
Ask the experts: http://www.sciam.com/askexpert/biology/biology38/
Biology Cartoons - Homeostasis and Postive Feedback:
http://www.colorado.edu/epob/academics/web_resources/cartoons/homeo.html
Biology-online: http://www.biology-online.org/AP/23_homeostasis.htm

The Science Key Concepts Series consists of 16 videos:
for Biology: Cells and Tissues, Cellular Energy and Metabolism, Energy Transfer & Biogeochemical Cycles, Homeostasis, Sensory Responses and Tropisms
for Physics: Electricity and Magnetism, The Electromagnetic Spectrum, Force and Motion, Molecular Motion, Waves
for Chemistry: Applied Chemistry, Electrochemistry, Radioactivity, Reactions and Energy Changes, Reactivity of Elements, Uses of Natural Resources

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